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PUBLIC HEALTH REPORTS

VOL. 34

JANUARY 24, 1919

No. 4

EPIDEMIC INFLUENZA.

PREVALENCE IN THE UNITED STATES.

While the reports indicate changes from week to week in the number of cases of influenza in the different States, there appears to be little change in the general situation throughout the country. Cases of influenza are reported from all States from which information is secured, and the distribution of the disease appears to be general.

Reports from State health officers for the week ended January 18, 1919, indicate increases in the number of cases notified, as compared with the preceding week, in Alabama, Arkansas, Connecticut, Florida, Louisiana, North Carolina, Oregon, South Carolina, Vermont, Virginia, and Washington.

Decreases in the number of reported cases are noted in the following-named States: California, Indiana, Iowa, Kansas, Maine, New Jersey, Ohio, and Oklahoma. (See summary of reports, p. 133.)

The reports from zones surrounding Army camps show an increase of about 25 per cent in the number of cases notified as compared with the preceding week. (See p. 137.)

CODE OF LIGHTING FOR FACTORIES, MILLS, AND OTHER WORK PLACES.

The following is a report of the divisional committee on lighting, section on sanitation, committee on welfare work of the committee on labor, advisory commission, Council of National Defense.

This report is published by permission of Mr. Samuel Gompers, chairman of the committee on labor.

The chairman of the divisional committee states that the rules, as set forth herein, have been officially approved by the Illuminating Engineering Society and have been tried out for several years under working conditions in factories, mills, and other work places.

These rules constitute the basis of the Pennsylvania factory lighting code, which became effective in the labor laws of that State June 1, 1916; also the basis of the New Jersey lighting code, which went into effect in that State on August 1, 1916.

The appendix, containing the supplementary notes, was abstracted from the factory lighting code of the Illuminating Engineering Society.

The committee recommends that steps be taken at once to put the code into effect in every State in the country. For purposes of legislative enactment the rules alone may suffice.

The divisional committee on lighting was composed of the following members:

L. B. Marks, chairman, consulting engineer, 103 Park Avenue, New York City.

C. E. Clewell, assistant professor, electrical engineering, University of Pennsylvania, Philadelphia, Pa.

A. S. McAllister, consulting engineer, 261 West Twenty-third Street, New York City.

Preston S. Millar, general manager, electrical testing laboratories, East End Avenue and Eightieth Street, New York City.

Fred J. Miller, works manager, Remington Typewriter Co., 374 Broadway, New York City.

William J. Serrill, engineer of distribution, United Gas Improvement Co., Philadelphia, Pa.

G. H. Stickney, illuminating engineer, Edison Lamp Works, Harrison, N. J.

Part 1.—Prefatory Note.

When adequate and satisfactory illumination is substituted for the all too prevalent poor illumination in factories, mills, and other work places the results obtained are mutually beneficial to the employees, the employers, and the country as a whole. Under proper illumination conditions the health, contentedness, safety, and skill of the employees are maintained at a high standard, the output is increased in quantity and improved in quality, while there is a proportional reduction in the cost of each unit of finished product when it reaches the public.

While it is desirable to have adequate light over the working areas it is absolutely essential for the proper results to eliminate or minimize the light which otherwise would pass directly from the lamps to the eyes of the workers; that is, one must avoid *glare*, which is not only fatiguing to the eye but also conducive to the incorrect estimation of sizes and locations of objects in the field of view.

Glare effects may be caused not only by the light reaching the eye directly from the sources having a brightness greatly in excess of that of the objects viewed, but they may be produced by excessive reflections from the objects within view. In factory lighting each lamp should be so located that the eye does not see it in the ordinary course of work, and so shaded or covered that brilliant reflections are avoided. The desired result can be obtained by putting over the lamp an open shade which screens it and reflects downward much of the light which would otherwise be of either no value or actually

detrimental. Another way of accomplishing the same result is to surround the lamp with a diffusing globe dense enough not to reveal the form of the actual light source within, but to give the effect of the light pouring from the globe as a whole. Specific suggestions for various locations are contained in the appendix herewith.

General requirements of artificial lighting.—The requirements for good illumination in factories, mills, and other work places may be summarized as follows:

1. Sufficient illumination should be provided for each workman irrespective of his position on the working space.

2. The lamps should be properly selected and so installed as to avoid or minimize strain on the eyes of the workmen. The type and size of lamp should be adapted to the particular ceiling height and class of work in question.

3. The lamps should be operated from sources of supply which will insure continuity of service and steadiness of light.

4. Adequate illumination should be provided from overhead lamps so that sharp shadows may be prevented as much as possible, and in such measure that individual lamps close to the work may be unnecessary except in special cases.

5. In addition to the illumination provided by overhead lamps, individual lamps should be placed close to the work if they are absolutely necessary, and in such cases the lamps should be provided with suitable opaque reflectors.

These requirements may now be met by means of the new types of electric and gas lamps, one type of which can usually be found for practically each factory and mill location, specially adapted to the general physical conditions of the location and character of the work in hand.

Advantages of good light.—While the necessity of good light is so evident that a list of its effects may seem commonplace, these same effects are of the greatest importance in their relation to factory and mill management. The effects of good light, both natural and artificial, and of bright and cheerful interior surroundings, include the following:

1. Reduction of accidents.
2. Greater accuracy in workmanship.
3. Decreased spoilage of product.
4. Increased production for the same labor cost.
5. Less eye strain.
6. Better working and living conditions.
7. Greater contentment of the workmen.
8. Better order, cleanliness, and neatness in the plant.
9. Easier supervision of the men.

In this list it will be noted that items 5, 6, 7, 8, and 9 all have a bearing on accident prevention.

The following code gives in the briefest possible form the essentials of proper and adequate lighting for factories, mills, and other work places, general information with detailed discussion of the methods of applying the code being presented in the appendix:

Part 2. Rules.

RULE 1. General requirement.—Working or traversed spaces in buildings or grounds shall be supplied during the time of use with artificial light in accordance with the following rules when natural light is less than the intensities specified in rule 2.

RULE 2. Intensity required.—The desirable illumination to be provided and the minimum to be maintained are given in the following table:

	Foot-candles ¹ at the work.	
	Ordinary practice.	Minimum.
(a) Roadways and yard thoroughfares.....	0.05—0.25	0.02
(b) Storage spaces.....	.50—1.00	.25
(c) Stairways, passageways, aisles.....	.75—2.00	.25
(d) Rough manufacturing, such as rough machining, rough assembling, rough bench work.....	2.00—4.00	1.25
(e) Rough manufacturing, involving closer discrimination of detail.....	3.00—6.00	2.00
(f) Fine manufacturing, such as fine lathe work, pattern and tool making, light-colored textiles.....	4.00—8.00	3.00
(g) Special cases of fine work, such as watchmaking, engraving, drafting, dark-colored textiles.....	10.00—15.00	5.00
(h) Office work, such as accounting, typewriting, etc.....	4.00—8.00	3.00

¹ The foot-candle, the common unit of illumination, is the lighting effect produced upon an object by a standard candle at a distance of 1 foot; at 2 feet the effect would be not one-half foot-candle, but one-fourth foot-candle, etc. A lamp which would give off 16 candlepower uniformly in all directions would produce a uniform illumination of 1 foot-candle at a distance of 4 feet in any direction.

NOTE.—Measurements of illumination are to be made at the work with a properly standardized portable photometer.

RULE 3. Shading of lamps.—Lamps shall be suitably shaded to minimize glare.

NOTE.—Glare, either from lamps or from unduly bright reflecting surfaces, produces eye strain and increases accident hazard.

RULE 4. Distribution of light on work.—Lamps shall be so installed in regard to height, spacing, reflectors, or other accessories as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensity.

RULE 5. Emergency lighting.—Emergency lamps shall be provided in all work-space aisles, stairways, passageways, and exits, to provide for reliable operation when, through accident or other cause, the regular lighting is extinguished. Such lamps shall be in operation concurrently with the regular lighting and independent thereof.

RULE 6. Switching and controlling apparatus.—Switching or controlling apparatus shall be so placed that at least pilot or night lights may be turned on at the main points of entrance.

Part 3.—Appendix—General Information and Suggestions.

SECTION 1. DAYLIGHT:

Adequate daylight facilities through large window areas, together with light cheerful surroundings, are highly desirable and necessary

features in every work place, and they should be supplied through the necessary channels, not only from the humane standpoint but also from the point of view of maximum plant efficiency.

Importance of daylight.—The unusual attention to gas and electric lighting in factories, mills, and other work places during the past few years, the perfection of various lamps and auxiliaries by means of which an improved quality and quantity of lighting effects are obtained, and the care which has been devoted to increasing the efficiency in various industrial operations—all go to emphasize the many advantages and economies that result from suitable and adequate window space as a means for daylight in the proper quantities and in the right directions during those portions of the day when it is available.

Three considerations.—Three important considerations of any lighting method are *sufficiency*, *continuity*, and *diffusion*. With respect to the daylight illumination of interiors, *sufficiency* demands adequate window area; *continuity* requires (a) large enough window area for use on reasonably dark days, (b) means for reducing the illumination when excessive, due to direct sunshine, and (c) supplementary lighting equipment for use on particularly dark days, and especially toward the close of winter days; *diffusion* demands interior decorations that are as light in color as practicable for ceilings and upper portions of walls, and of a dull or mat finish, in order that the light which enters the windows or that which is produced by lamps may not be absorbed and lost on the first object that it strikes, but that it may be returned by reflection, and thus be used over and over again. Diffusion also requires that the various sources of light, whether windows, skylights, or lamps, be well distributed about the space to be lighted. Light-colored surroundings, as here suggested, result in marked economy, but their main object is perhaps not so much economy as to obtain a result that will be satisfactory to the human eye.

Requirements.—The following requirements may now be listed for natural lighting:

1. The light should be adequate for each employee.
2. The windows should be so spaced and located that daylight conditions are fairly uniform over the working area.
3. The intensities of daylight should be such that artificial light will be required only during those portions of the day when it would naturally be considered necessary.
4. The windows should provide a quality of daylight which will avoid a glare due to the sun's rays and light from the sky shining directly into the eye, or where this does not prove to be the case at all parts of the day, window shades or other means should be available to make this end possible.

5. Ceilings and upper portions of walls should be maintained a light color to increase the effectiveness of the lighting facilities from window areas. The lower portions of walls should be somewhat darker in tone to render the lighting restful for the eye. Factory green or other medium colors may be used to good effect.

Classification.—Means for natural lighting may be classed under three broad divisions, as follows:

(a) That case in which the windows are located on the sides of the building or in the framework of saw-tooth construction, where diffused light from the sky reaches the work during a large portion of the day.

(b) That case in which windows are located overhead on a horizontal or nearly horizontal plane in the form of skylights, thus furnishing direct light from the sky during a large portion of the day.

(c) That case in which prismatic glass takes up the direct light from the sky and redirects it into the working space.

Method (a) is, of course, the most common of the three, and it may be noted that the saw-tooth or other roof-lighting constructions have become very popular and result in an excellent quality and quantity of light for given window areas provided the size and location of windows are in accord with modern practice.

Increasing the value of floor space.—Adequate and well-distributed natural light means that certain portions of the floor space which ordinarily would not be available for work are converted into valuable manufacturing space. In a general way, therefore, the average factory, mill, or other work place, if properly designed, should possess natural lighting facilities which produce the best practicable distribution of daylight illumination.

Wide aisles.—With low ceilings and very wide aisles, workmen located at the central portion of the building must sometimes depend for their natural light on windows located at a considerable distance away from their working position. In these cases it may be impossible, in general, to depend altogether on daylight over an entire floor space, even at those times of the day when daylight conditions would be entirely adequate under other circumstances. This statement applies to side windows rather than to skylights or to saw-tooth construction.

Varying conditions.—In a case of this kind employees located next to the windows are furnished with suitable daylight in the early morning and toward the latter part of the afternoon, the upper portions of the windows being particularly serviceable in lighting areas at some distance away from the windows. A southern exposure, however, results in such excessive light from the sky during the middle of the day that heavy shades are nearly always pulled down so as to cover the entire window area. This plan makes it necessary

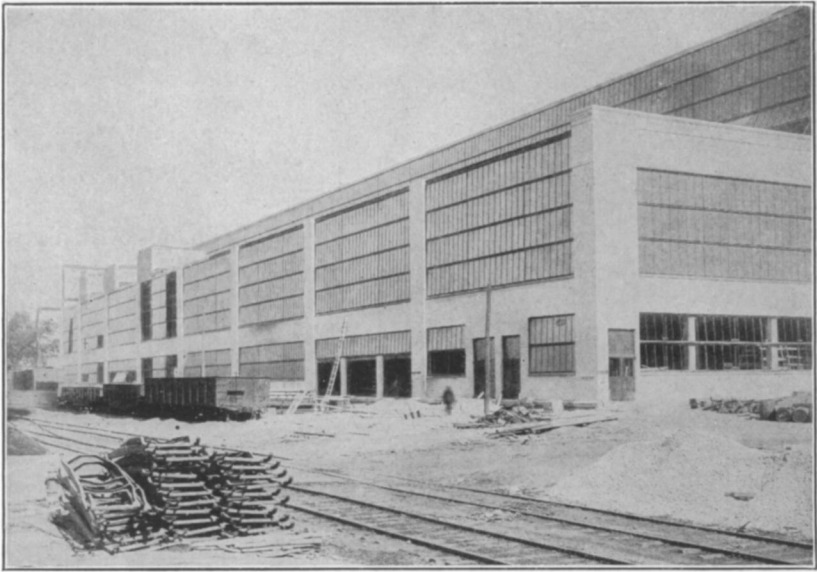


Fig. 1.—Modern building construction is tending toward the provision of large window areas. The foundry illustrated above will have an excellent quantity of natural light within, even in the dark winter days.

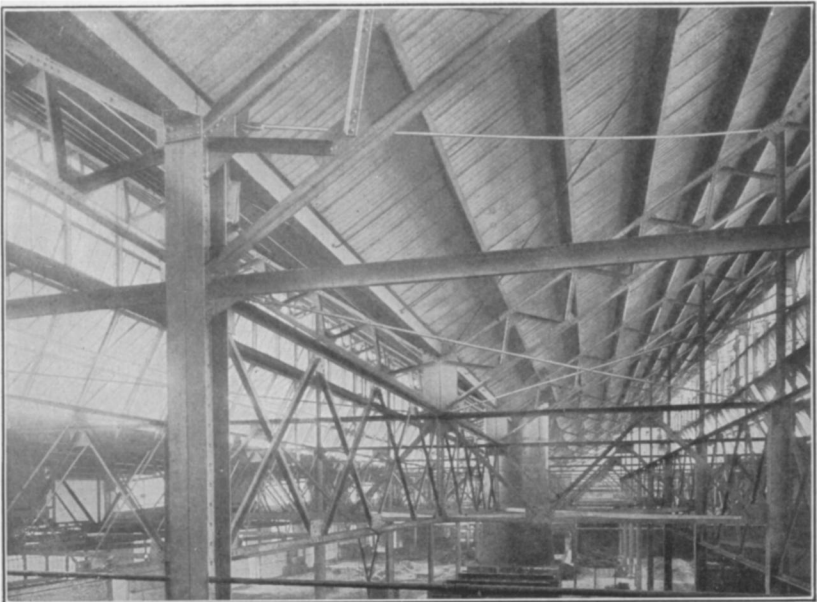


Fig. 2.—Light-colored walls and ceilings are important in economizing and diffusing both natural and artificial light. In this foundry the daylight reflected from the sloping roof contributes to the illumination on the work.

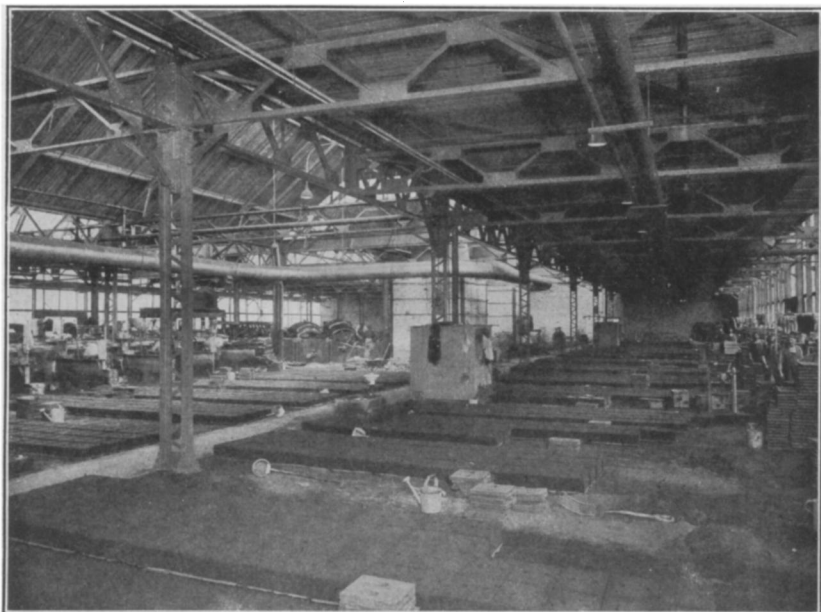


Fig. 3.—Even in wide buildings of one story, excellent illumination can be secured throughout by a proper arrangement of windows and skylights. In this foundry side-wall windows are supplemented by windows nearly vertical in the roof. Windows should be so arranged and glazed as to avoid objectionable glare.

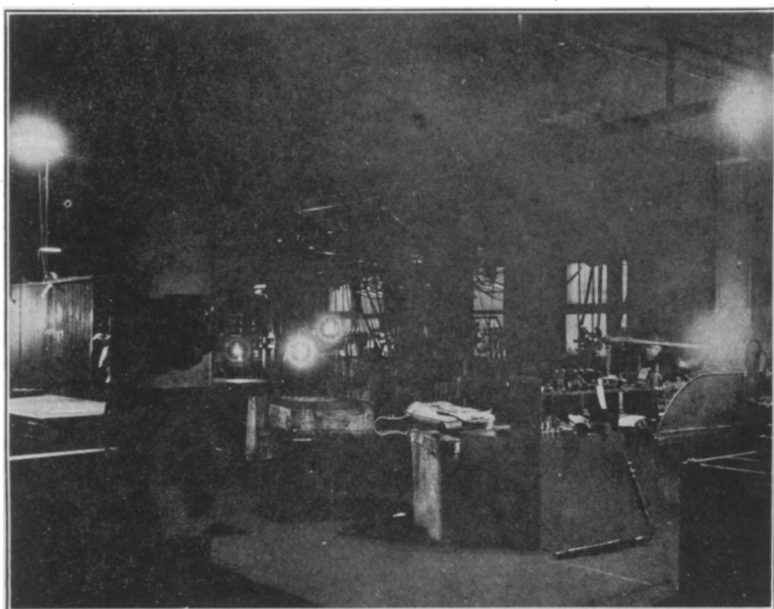


Fig. 4.—This machine shop is unsafe and inefficient because of inadequate artificial light, poor distribution, and excessive glare. Note the brilliant light shining on the face of the workman at the right of the illustration.

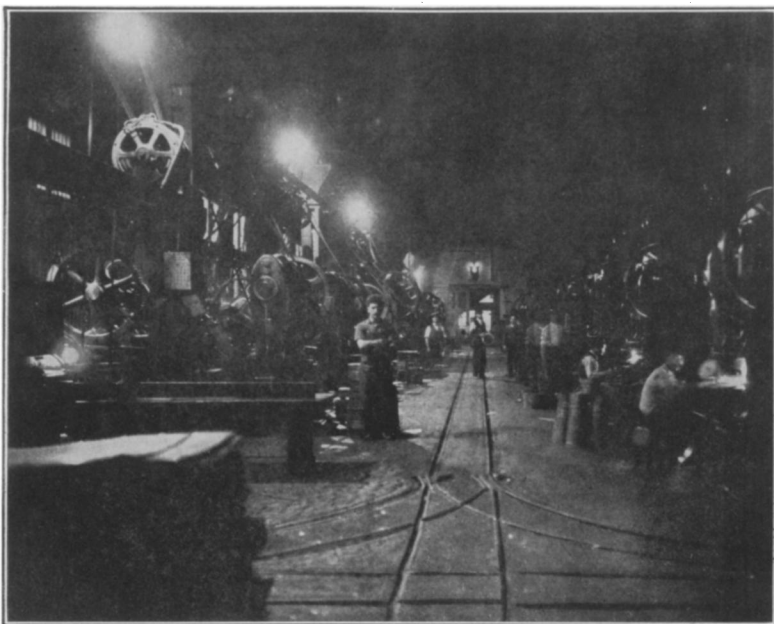


Fig. 5.—In this punch press room the overhead lamps are located so that important parts of the work are in shadow. The unshaded local lamps glare in the workman's eyes. The dark ceiling makes the room appear gloomy. If the large lamps were suspended in front of the machines instead of behind, few if any local lamps would be needed. These should be shaded.

to use artificial light throughout the larger part of the office during the brightest portion of the day and reduces the daylight at those points where it would supposedly be the best—namely, near the windows. Here the location of the windows is a large factor in the excellence of the daylight conditions but the manipulation of the shades is perhaps even more important. To avoid such a difficulty, adjustable translucent upper window shades with adjustable opaque lower shades might be employed.

Upper portions of windows.—It should be further noted in this illustration that the upper portions of the windows give a reduced illumination in proportion to their areas, to the floor space near them. In rooms of moderate size, therefore, the windows should be placed as near the ceiling as practicable. When the sun shines through windows so located, the direct light must be reduced or diffused. This may be accomplished by the use of ribbed glass in ordinary factory and mill buildings, and in offices by the use of translucent sunshades or awnings.

Tempering the light.—The light due to the sunshine on such shades and awnings will be as bright as ordinary skylight if the shade is well chosen, and the ribbed glass will be still brighter. If the windows are large, the illumination is likely to be too great near the windows, as previously pointed out, and it must be reduced. This should not be done, however, by pulling down an opaque shade over the top of the windows, because the top portion of the window is the part that is particularly needed to give light to the interior of the room. The better scheme is to employ an opaque shade *which should be raised from the bottom of the window*. This will reduce the illumination near the window without affecting it over the interior of the room to any marked degree.

Window glasses.—Both translucent and clear glass are employed for factory and mill windows. There is a slight reduction in the transmitted light through ordinary translucent wire glass, but it is often required by insurance regulations for a deduction in the fire risk where a given building is located in close proximity to other buildings. Wire glass is also used quite generally with steel window frames, here being an added protection from the standpoint of fire risk. Wire glass may be obtained in clear form, but its expense in contrast to the translucent form is such as ordinarily to prohibit its use for industrial purposes.

Wire glass.—Wire glass, also known as ribbed glass, should be used and is advocated for practically all factory and mill windows where prisms are not required. Wires of rather open mesh cause so little reduction in light as to warrant no mention of this feature. Special care should be taken to get such glass as is smooth both on the flat

side and on the ribbed side to facilitate cleaning. Wire or ribbed glass gives better diffusion than plain glass.

Prism glass.—Where the sky outside of the windows is obstructed by buildings, prism glass is recommended if the room is deep. Different kinds of prisms can not be used to advantage interchangeably. The amount of prism glass required in any case depends much upon the surroundings, and to obtain excellent results of which such glass is capable it must be used intelligently.

Skylights.—Skylights are sometimes installed in long, narrow, continuous strips in a sloping roof. The ribs of the ribbed glass are generally so arranged that it is convenient to make them at right

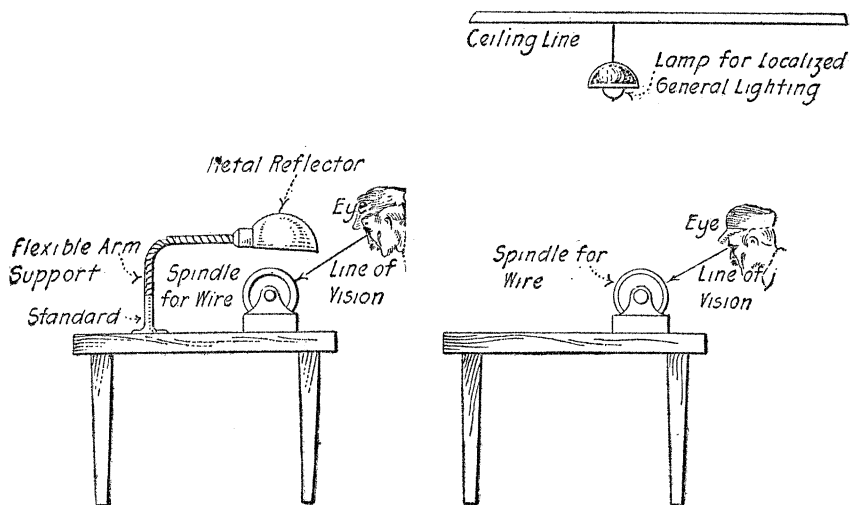


FIG. 6.—While the reflector as shown shades the eyes of the workman and gives a good intensity on the work, the lighting effect may be poor unless other illumination is provided for the surroundings. Too great a contrast between the light on the work and on its surroundings is a common cause of glare. Compare with Fig. 7.

FIG. 7.—Larger lamps hung higher usually provide good light on the work and sufficient surrounding illumination to avoid glare. For some classes of work, such as lathe work, lamps should be located further to the right so as to illuminate the front of the machine.

angles to the length of the strips. The result is that the sunshine is diffused by the ribs over a narrow area parallel to the strip of skylight, thus lighting one part of the room much more brilliantly than the remainder. If the ribs are installed to run parallel to the strips, they will give a much more general distribution of the sunlight. In the foregoing, the word *strip* refers to the long belt of skylight and not to the individual sheet of glass. Ribbed glass in vertical windows should generally be placed with the ribs horizontal. They thus roughly fulfill some of the functions of prisms.

Dirt accumulations.—While translucent wire or ribbed glass reduces the amount of light transmitted through the windows, the roughness of the outside surface of such glass often causes accumu-

lations of dust and dirt, which are more to blame for the reduction of transmitted light in some cases than the translucent nature of the glass itself. Remedies of this difficulty are to secure smooth glass and to resort to frequent cleaning.

Wire glass as a safeguard.—Wire glass for skylights is, of course, a practical necessity as a safeguard against accidents due to accidental breakage of the glass or due to objects falling on top of the glass.

Sunshine not desirable.—In all the work of providing natural light it should be kept in mind that direct sunshine in itself, from the illumination standpoint but irrespective of sanitary conditions is not wanted. The idea that sunshine is the important item is a common but an erroneous impression. For example, in saw-tooth construction the windows do not face the south to get all the sunshine possible, but they face the north to exclude the sunshine. Ordinary windows, on the other hand, face all directions because not enough light can be distributed to interiors from north windows alone. Windows on the other than north fronts admit sunshine to be sure, and this makes sunshades and awnings necessary to exclude the excessive brightness.

SECTION 2. VALUE OF ADEQUATE ILLUMINATION :

Factory and mill owners are concerned in the matter of securing the largest output for a given manufacturing expense. An improved machine tool capable of increasing the product for given labor costs is most attractive, provided its first cost is within returnable limits out of the larger profits. Improved small tools, better methods of handling material, adequate crane service, fire protection, good shop floors, accurate and efficient time-keeping methods, and similar items, vitally concern the shop manager; money is expended to realize excellence in these features, because they afford increased economies and protection, thus resulting in a higher efficiency of the plant.

Energy consumption a minor item.—Many arguments leading to the sale of gas and electric lamps for use in factory and mill buildings are based on reducing the lamp operation cost by substituting a new for an older system. Arguments of this kind are of value, however, only when such a reduction in operation cost can be effected without sacrifice in the adequacy of the illumination. It would be a poor policy, in the extreme, to argue a saving in energy consumption by the substitution of one type of lamp for another on a basis of equal candlepower in both old and new systems.

Effect of good light on production.—Arguments of a convincing nature, which insure to the factory or mill manager an increased output through improved illumination service, are of importance and even greater at times than reductions in the cost of illumination for the same quantities of light. In view of the fact that resulting ad-

vantages of superior illumination on increased output are apt greatly to exceed economies in operation cost as regards the lighting system, it is a distinct advantage to direct and hold the attention on the former rather than on the latter. This statement will be more apparent when interpreted into definite items as follows:

Interpreting the advantages of good light.—While the major consideration in the eyes of the factory or mill owner is undoubtedly and quite naturally the money value of good light in the larger return of both quantity and quality of work which may result from

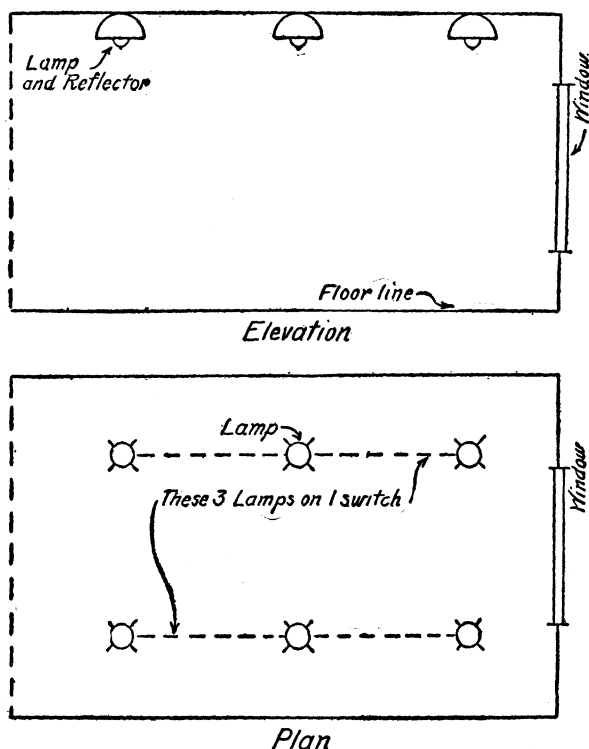


FIG. 8.—This illustrates an uneconomical arrangement of control, since lamps near the windows can not be turned off independently of those more remote. Compare with Fig. 9.

the installation of a superior as compared with an inferior lighting system, it should be noted that it is very difficult to interpret into dollars and cents the value of good light made possible by such returns. This difficulty is due to the necessity of keeping all conditions in a factory or mill section absolutely constant while varying the amount of illumination from poor to good conditions in an effort to determine the output and its dependency on the lighting facilities. *As accurate data become available*, giving the increases in production for certain specific improvements in artificial lighting, it will doubtless prove helpful to a proper interpretation of adequate light and its worth to any plant.

Practical example.—Continuing from the manufacturer's point of view, it may be said that certain assumptions as to energy cost, cleaning, interest, and depreciation show that the annual operation and maintenance cost for the illumination of a typical shop bay of 640 square feet area may be taken at \$50. If five workmen are employed in such a bay at an average wage of, say, 25 cents per hour, the gross wages of the men in such a bay, plus the cost of superintendence and indirect shop expense, may equal from \$5,000 to \$7,000 per annum. In a case of this kind, therefore, the lighting

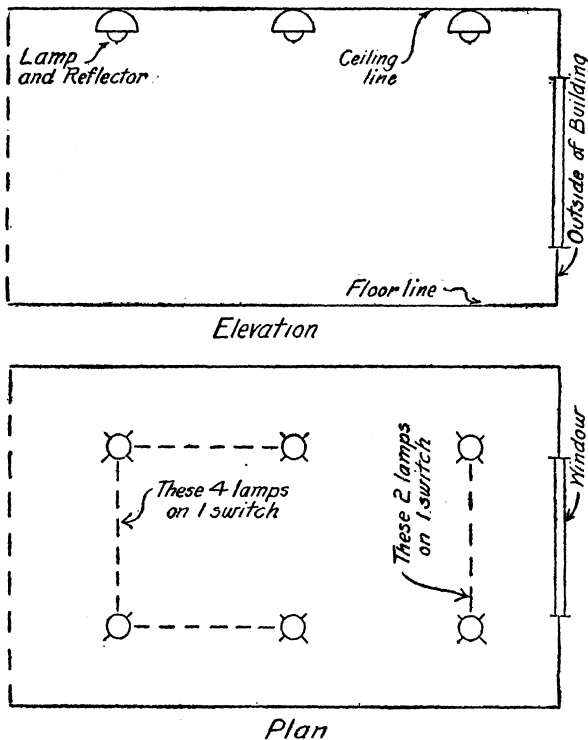


FIG. 9.—This scheme of control in groups parallel to the windows is an improvement on that shown in Fig. 8, permitting lamps in the dark parts of the room to be turned on and those near the windows to be turned off during the hours of fading daylight, when the latter are unnecessary.

will cost from seven-tenths to 1 per cent of the wages, or the equivalent of less than four to six minutes per day. We may roughly say that a poor lighting system will cost at least one-half this amount (sometimes even more through the use of inefficient lamps and a poor arrangement of lamps), or the equivalent of, say, two to three minutes per day. Nearly all factories and mills have at least some artificial light; hence, in general, if good light enables a man to do better or more work to the extent of from two to three minutes per day the installation of good lighting will easily pay for the difference between good and bad light through the time saved for the workmen.

Actual losses.—Superintendents have stated in actual instances that due to poor light their workmen have lost much time, sometimes as much as from one to two hours per day on certain days. If good light will add an average of, say, one-half hour per day to the output, these 30 additional effective minutes represent an increase in output of 5 per cent, brought about through an expenditure equal to one-half of 1 per cent of the wages for improved lighting, or a saving equal to ten times the expense.

SECTION 3. OLD AND NEW LAMPS.

The inadequate means available for illumination by artificial methods in the past have contributed to the slowness of an appreciation of the features of artificial light which influence the working

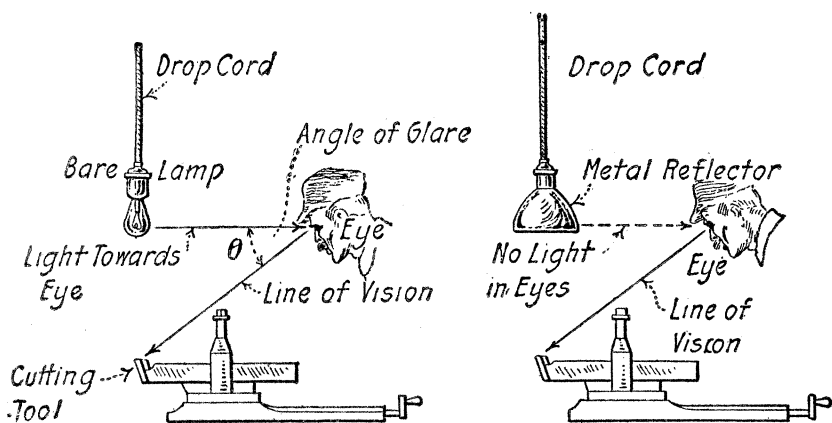


FIG. 10—These companion diagrams illustrate the importance of a reflector for local lighting. The reflector as shown at the right shades the eyes of the workman and increases the light on the work.

efficiency of the eye. Open-flame gas burners, carbon incandescent and arc lamps, practically the only illuminants available 10 years or so ago, play but a small part in the present approved methods of factory and mill lighting.

New lamps.—The large variety of comparatively new lamps available for factory and mill lighting includes the mercury vapor, metalized filament, tungsten, gas-filled tungsten, metallic flame or magnetite arc, the flame carbon arc, the quartz mercury vapor, and various types of gas arc lamps. Remarkable improvements have thus been made in both the electric and gas lighting fields, the same general rules of applying the lamps covering both of these fields. Possibilities in factory and mill lighting are now attainable which before the introduction of these new lamps were either unthought of or impossible. Consideration of the eye as a delicate organ, together with the new ideas of the items which affect its comfort and effi-

ciency, have resulted in establishing certain principles in illumination work and have directed attention naturally and in a growing manner to the proper use and application of these new lamps.

SECTION 4. EFFECTS ON FACTORY AND MILL LIGHTING PRODUCED BY MODERN LAMPS:

With the introduction of these new gas and electric lamps broader possibilities have been presented in factory and mill lighting. The use of units of sizes adapted to the purposes allows results which it has been hitherto impossible to obtain satisfactorily, either by the arc lamp, carbon filament, or open-flame gas burner, formerly available.

New possibilities.—It is evident that the introduction of the many new lamps has made possible what may be termed a new era in industrial illumination, a distinctive feature of which is the scientific installation of the lighting units, suiting each to the location and class of work for which it is best adapted. Before the availability in recent years of medium-sized gas and electric units the choice of the size of unit for a given location was often no choice at all. In many cases, due to small clearance between cranes and ceilings or other conditions making it necessary to mount the lamps very high above the floor, but one size or type of unit was available—the carbon filament or open-flame gas burner in the former and the arc lamp in the latter case.

Low ceilings.—For low ceilings, up to 18 feet, the use either of carbon filament, open-flame gas burner, or arc lamps resulted usually in anything but uniform light over the working plane and often produced merely a low general light, which was practically useless for the individual machine. In such instances individual lamps had to be placed over and close to the machines. With this arrangement relatively small areas are lighted by each lamp, and the metal shades usually employed serve only to accentuate the “spot lighting” effect. Such a form of illumination for factory and mill work is unsatisfactory and inefficient, but, as stated, was in the past in many cases the only available scheme. *The absence of lamps of the proper size is no longer an excuse for the existence of such conditions in industrial plants.*

SECTION 5. OVERHEAD AND SPECIFIC METHODS OF ARTIFICIAL LIGHTING.

Factory and mill lighting may be classified under two general divisions—first, distributed illumination furnished from lamps mounted overhead; and, second, specific illumination furnished by individual lamps located close to the work. For practical purposes this classification is sufficient. In numerous cases a combination of these two methods becomes necessary.

Mounting the lamps high.—Where the lamps are high enough to be out of the line of ordinary vision, and are of a size and so spaced as to furnish illumination at any position of the floor where work may be carried on, the system is referred to as the *overhead method* of lighting. This method has many advantages. Its general adoption, which has been somewhat slow, has increased with the appearance of the many new types of lamps and with the growing appreciation of the value of good lighting.

Where a small amount of general or overhead lighting is coupled with specific lighting from individual lamps, a large part of the floor space in many shops is in relative darkness, and much dependence must be placed on the hand lamps close to the work. The small number of overhead lamps generally used in such cases, furnishes merely a small amount of additional illumination over the floor space which is not sufficient to be of much value. However, where sufficient intensity is provided by general illumination, this is often a very effective means of lighting a large work room.

Low ceilings.—Locations with low ceilings, until recently, have been lighted by the individual hand-lamp method, because the old carbon-filament lamps, being of low candlepower, could not well be used close to the ceiling, while the old type of arc lamp was often impracticable, due to its large physical size, as well as its relatively high candlepower. This statement is subject to some modification, because low candlepower units have sometimes been used in clusters for low ceilings as a compromise between a single small or a single large unit, this scheme being, however, usually insufficient and unsatisfactory in comparison with modern methods of lighting. In a particular manner, therefore, suitable illumination has been difficult with low ceilings.

New types of gas and electric lamps have a range of candlepower from very low to very high values, and the overhead system with the elimination of individual lamps is thus possible; in other words, a size of gas or electric lamp may now be selected from a large available list of sizes for nearly every factory or mill condition.

SECTION 6. LIGHTING CIRCUITS FOR ELECTRIC LAMPS AND SUPPLY MAINS FOR GAS LAMPS:

The question of lighting circuits is mentioned here with particular reference to factory and mill conditions, where motor loads are apt to be large in comparison to the energy consumption of electric lamps which are in service. In some cases, the proportion of motor load to lighting load is in the ratio of 10 to 1, in others 7 to 1, and so on, and the varying demands on the circuits by motors may greatly affect the lamps. Hence it is important to maintain strictly separate supply circuits for the lamps in order to avoid varying voltage which is apt to result if the motors are connected to the same circuits with the lamps.

Constant voltage.—In addition to the superior illumination resulting from lamps supplied from constant voltage mains, some types operate with longer life or very much better mechanically when supplied with constant voltage than otherwise. These features will therefore generally more than offset the somewhat greater cost of maintaining separate circuits for each class of service. In like manner and for similar reasons, it is advisable to place gas lamps on supply lines separate from those delivering gas for power purposes.

SECTION 7. CONTROL OF LAMPS AND ARRANGEMENT OF SWITCHES:

The control of lamps in factory and mill lighting is important in all cases, but especially so where a large number of lamps is used in preference to a small number for a given floor area. For example, where an overhead system of tungsten lamps of small size is used, a large number will, of course, be necessary for a given floor area, and in such cases the number of control circuits may at times seem excessive when planned out for sufficient flexibility of operation. Such circuits, however, in rendering the system more flexible, will be more than paid for by the saving in energy and maintenance due to the turning out of lamps not needed in certain sections of the factory or mill, provided the number of hours per day during which the lamps are used on the average is relatively large, and the differences in daylight intensities over the floor area are also relatively large.

Control parallel to windows.—The lamps most distant from the windows will usually be required at times when the natural light near the windows is entirely adequate, thus making it an advantage to arrange the groups of lamps in circuits parallel to the windows. The advantage of this method is further apparent when it is considered that if the lamps are controlled in rows perpendicular to the windows, all lamps in a row will necessarily be on at one time, while a portion only may be required.

Practical case.—The foregoing statement may be developed into a definite proposition. Thus, to install a single switch may involve, say, \$5 as its first cost. If 10 lamps are to be controlled from a single switch, these 10 lamps must obviously either all be turned off at a time or all turned on at a time. An additional switch at a cost of \$5 will permit either half of these 10 lamps being turned off, if not required at certain times, when the remaining five are needed. This extra switch may or may not be an economy. Consider, for example, the case where these five lamps are of the 60-watt tungsten type, and that they are turned off by the extra switch on an average of one-half an hour per day while the others are needed, or *vice versa*. In a year's time the energy saved at 1 cent per kilowatt-hour will amount to perhaps 50 cents. At this rate it will require 10 years for the energy saved to pay for the first cost of the extra switch. This would not be considered a distinct economy. If, however, the energy cost

be greater, and more nearly the average under actual conditions, or if the number of hours per day during which a portion only of the lamps will not be used be greater, then these values will be correspondingly modified.

Locating switches and controls.—In locating switches or controls in factory and mill aisles care should be exercised to arrange them systematically—that is, on columns situated on the same side of the aisle and on the same relative side of each column. This plan materially simplifies the finding of switches or controls by those responsible for turning on and off the lamps and is particularly important where a given floor space is illuminated by a large number of small or medium sized lamps distributed uniformly over the ceiling area, a feature which is usually accompanied by the use of a relatively large number of switches or controls.

SECTION 8. SYSTEMATIC PROCEDURE SHOULD BE FOLLOWED IN CHANGING A POOR LIGHTING SYSTEM OVER TO AN IMPROVED ARRANGEMENT:

When undertaking the change from an old to a new lighting system, the various forms of illumination which are adapted to factory and mill spaces should be studied and an investigation made of the various types of gas and electric lamps on the market which are available for the purpose.

Time should be allowed for a study of the given locations to be lighted; for preparing the plans of procedure in the installation of the gas or electric lamps and auxiliaries; and for customary delays in the receipt of the necessary supplies and accessories to the work in hand. Altogether, therefore, work of this kind requires considerable time for its completion.

Using the shop force.—In large factories or mills a wiring or gas-fitting force is sometimes a part of the maintenance division. The work of the wiremen or fitters is likely to be heaviest in the winter, due to the dark days. Where this condition exists there is all the more reason to apportion out new work so as to accomplish it during the months of least wiring and piping repair activity, and, further, at that time of the year when employees will be comparatively unaffected by the disturbances usually associated with a change from an old to a new lighting system through possible irregularities in the illumination service while the wiremen or fitters are at work.

Distribution of expense.—Another feature different from the foregoing viewpoint is in the distribution of the installation cost over a relatively long interval. If, for example, the system is desired for the approaching winter, the complete wiring or piping plans may be drawn up and blocked out into three, four or even more sections, thus spreading the expense over as many months.



Fig. 11.—In this well-lighted machine shop note the even distribution of light and freedom from glare. The illumination is economically concentrated on the work. As it appears in the illustration, additional light on the ceiling would render the room more cheerful.

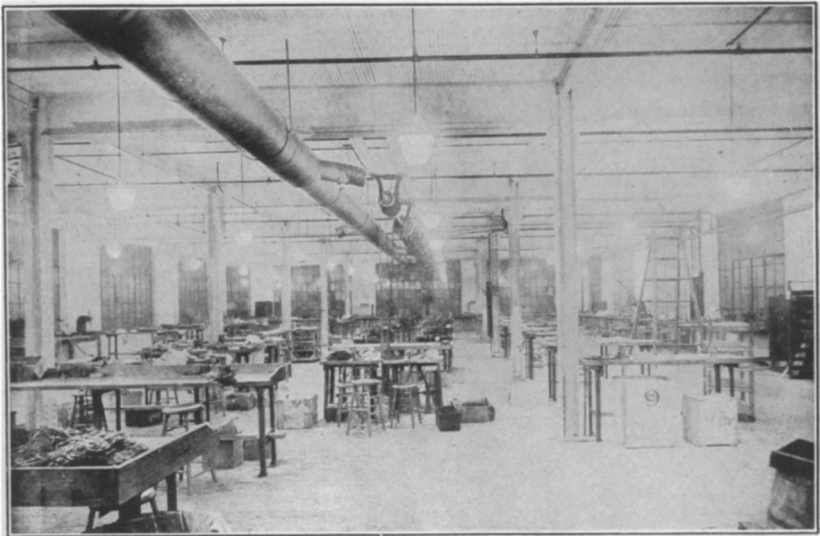


Fig. 12.—The light ceiling increases the cheerfulness of the factory in a remarkable manner. With white ceilings the excellent diffusion and even distribution obtainable with semi-indirect lighting amply justifies its slight additional cost, especially where fine detail must be seen.

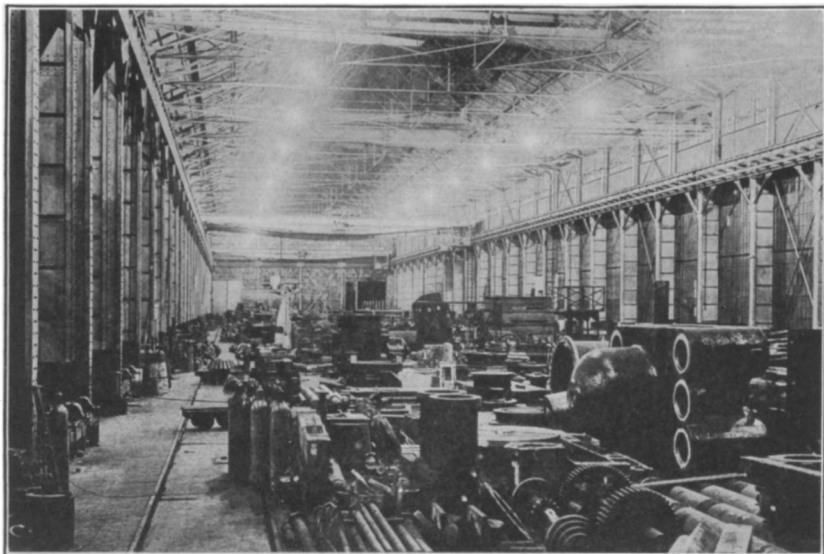


Fig. 13.—A good example of the illumination effect which can be secured by the overhead system of lighting. In this erecting shop the high mounting of the lighting units prevents brilliant light sources from causing objectionable glare. Note also the even light distribution and soft shadows.



Fig. 14.—A factory office illuminated by a general system of lighting, arranged to conceal brilliant light sources. Adequate light is provided without drop lamps at the desks. (See also Fig. 15.)

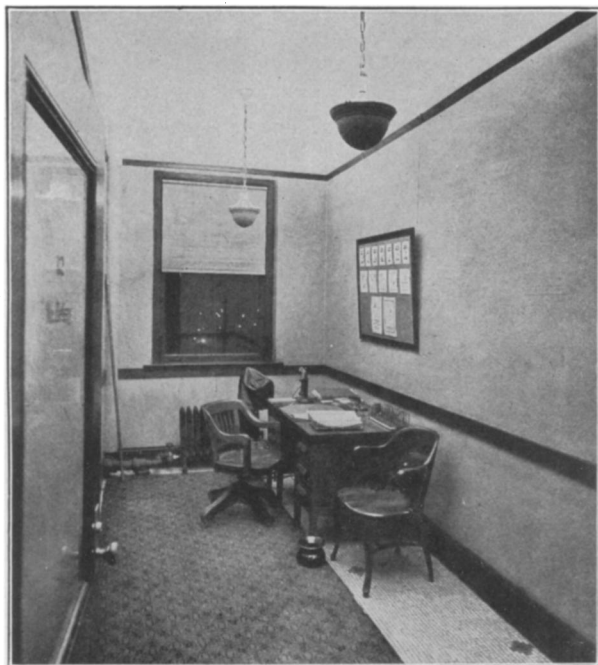


Fig. 15.—In this small office with indirect lighting, the illumination is produced by reflection from the ceiling. Note the even distribution of light on the desk surface and the absence of glare.



Fig. 16.—In this example of drafting room lighting, shadows are minimized by utilizing the white ceiling as the indirect source of light. The reflectors are so arranged as to conceal the lamps and spread the light evenly on the ceiling. Indirect methods of lighting are applicable only with white or light colored ceilings.



Fig. 17.—Benches near and facing the walls may be illuminated effectively by lamps placed high above the bench, as shown here. Proper reflectors, however, are important for the best results. Note that the location is such as to give good direction of light and avoid shadow cast by workman.

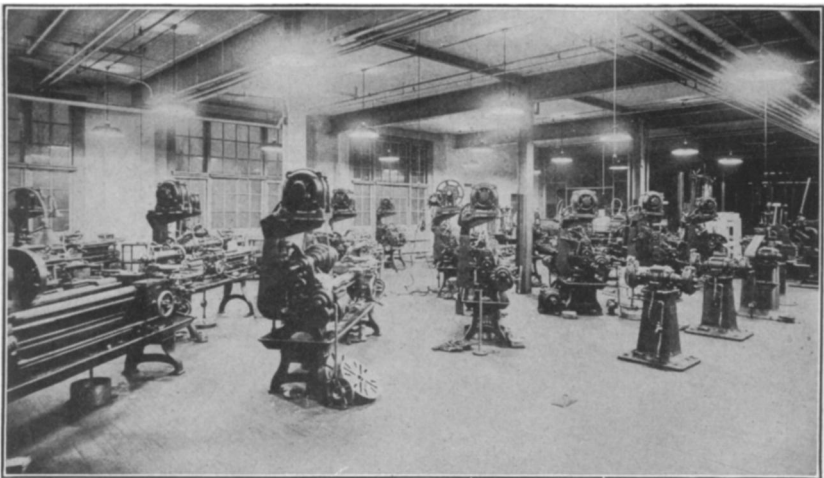


Fig. 18.—These machine tools are illuminated by a system of special fixtures for producing a well-diffused light with little or no glare. A supplementary shade conceals the lamp filament from view. Note the excellent distribution of illumination throughout this space.

Yearly appropriation.—In some shops a given appropriation may be allotted each year for building equipment. From the standpoint of finance plans, it may thus be desirable to distribute outlays of this nature over the year, rather than to concentrate them at any one time. *An important consideration in this method of installing lamps, however, is to prepare as far as possible the complete plans in advance, at least as regards given factory or mill sections, so as to insure a uniform and symmetrical installation as a whole when the component parts are finished.*

SECTION 9. REFLECTORS AND THEIR EFFECT ON EFFICIENCY:

A reflector or shade is used in conjunction with a lamp for the purpose of reducing the glare otherwise caused by looking directly into the bare lamp, as well as for the purpose of redirecting the light most effectively to the work.

Reflectors and shades, both metal and glass, are now obtainable for each size of incandescent electric and gas lamp. For a certain ratio between the spacing and the height of the lamps, a reflector can nearly always be selected which will furnish uniform illumination over the working surface.

Function of reflector.—Owing to the direction of the light from the lamp, nearly all types of lamps, in addition to the downward light, furnish some rays which go upwards and away in other directions from the objects to be illuminated, and are therefore relatively not useful. Furthermore, a bright source in the field of vision, causes an involuntary contraction of the pupil of the eye, which is equivalent to a decrease in illumination in so far as the eye is concerned. Hence, while reflectors or shades may at first seem to reduce the amount of light in the upper part of the room, their use actually increases the amount of light in a downward useful direction, and improves the "seeing" due to the better conditions which surround the eyes. The economic function of the reflector as contrasted to this easier condition it affords the eyes, is to intercept the otherwise useless or comparatively useless rays which do not ordinarily reach the work, and to reflect them in a useful direction. In performing this function, there is a choice through the design of the reflector, in the manner of distributing the light so as to make the illumination on the floor space uniform with certain spacing distances and mounting heights as previously mentioned.

Avoiding dark spots.—With the use of lamps for which a large variety of reflectors is available, the proper reflectors should therefore be chosen so as to give the desired distribution of light. In other cases, as in the use of the gas or electric arc lamps, where the globe or reflector is usually a fixed part of the lamp, care must be exercised

to space the lamps at sufficiently close intervals to insure uniformity of the illumination; that is, a freedom from the relatively dark spaces which exist between lamps when spaced too far apart.

Light interiors.—With a light ceiling, the reflection of that part of the light which passes through a glass reflector to the ceiling, and which is added to the light thrown downward from the under surface of the reflector, is a factor in building up the intensity of the illumination on the working surface. *Great importance is therefore attached to light interior colors, especially on ceilings and the upper portions of walls, both in reinforcing the direct illumination, and in giving diffusion, which in turn adds to the amount of light received on the side of a piece of work. It should also be stated that the intensity of the light from bare overhead lamps when measured on the working surface may be increased by as much as 60 per cent through the use of efficient reflectors.* This is due to the utilization of the horizontal rays of light as previously stated, which predominate in the bare lamp, whereas the most effective light in factory and mill-work is apt to be that which is directed downward.

Points to consider.—Reflectors will not be classified here from the commercial standpoint, but the following items should be given consideration in the selection of the type of reflector for factory or mill use:

1. Utilization efficiency—how much does the reflector contribute to the effective illumination on the work?
2. The effect in reducing glare.
3. Natural deterioration with age through accumulations of dust and dirt.
4. Ease in handling and uniformity of manufacture.
5. Physical strength and the absence of projections which may increase the breakage in case of glass reflectors.

A study of the various reflectors on the market with the aid of these items as a basis will determine what reflectors are best adapted to given conditions.

SECTION 10. SIDE LIGHT IMPORTANT IN SOME FACTORY AND MILL OPERATIONS:

It has been customary in many cases to measure the effectiveness of illumination in terms of the vertically downward component of the light. This method has ignored the value of side components in relation to vertical surfaces and openings in the side of the work. It is sometimes more necessary to light the side of the machine or the side of a piece of work than the horizontal surface. If, then, in designing a factory or mill lighting system the prime object is the production of the greatest amount of downward illumination, it may

happen that the side component is so small that the sides of machinery or of work are inadequately lighted.

Two ways to secure side light.—Experience indicates that there are two general ways in which to secure adequate side lighting. One of these methods is to lower the lamps, and the other is to use broader distributing reflectors than are called for by the rules which consider uniformity of the downward illumination only. Side walls or other reflecting surfaces will modify the results. Thus, after the determination of a certain type of reflector for producing uniform vertically downward illumination, it may be found that more side light is necessary, and this extra side component may, as stated, usually be secured by selecting a somewhat more distributing reflector. Broader distributing reflectors are apt to result in less downward illumination and will sometimes call for larger lamps than found necessary by preliminary calculations.

Practical case.—As an illustration, in a certain lighting system a vertically downward intensity of about 3 foot-candles was deemed sufficient for the work involved. Measurements and observations showed that the side light was insufficient. In this particular installation it was found necessary to produce a vertically downward intensity of about 5 foot-candles on the average in order to secure an intensity of about 2 foot-candles on the side of the work, and also to use a somewhat broader distributing reflector than at first chosen. Two foot-candles on the sides of the work were sufficient in this case where bench work and work in the vise on small machine parts were conducted.

Keeping the lamps high.—It is recommended that the lamps be mounted near the ceiling in all reasonable cases where side light is necessary, and that the side light be increased *not by lowering the lamps* but through the medium of broader distributing reflectors and larger lamps, if required. This attitude is taken on account of the glare which results when lamps are mounted too close to the work, a feature most noticeable in the absence of a reflector or where glass reflectors are used.

SECTION 11. MAINTENANCE.—PROVISION SHOULD BE MADE FOR SYSTEMATIC UPKEEP OF NATURAL AND ARTIFICIAL LIGHTING:

Windows.—Factory and mill windows become covered in time with dirt and produce greatly decreased values of natural light in consequence. These losses may easily be great enough to affect the workmen seriously and to necessitate the use of artificial light at times when otherwise it would not be required. Dark surroundings also increase the likelihood of accidents. Regular window cleaning should therefore be a part of the routine of every factory and mill building or group of buildings.

Lamps.—Carbon filament, mercury-vapor, gas-mantle, and tungsten lamps burn out or break, globes and reflectors become soiled, and the various other items of deterioration take place so gradually that in many cases they are given no special concern in the practical economy of the shop. Moreover, it is hardly necessary to mention the fact that often lighting systems are allowed to deteriorate to an extreme point, and nothing is done unless complaints come in from employees after the lighting facilities here and there throughout the shop have become so poor that work has to be discontinued temporarily. The losses of time from such circumstances, when added up throughout a year, are more than likely to exceed the expense of systematic attention to such maintenance items in advance.

Overhead system.—Furthermore, with modern methods, where the lamps are usually mounted overhead rather than close to each machine, the importance of relieving the workmen from any care of the lamps and placing it in the hands of a maintenance department is even greater than has been the case in the past, particularly in large plants.

A method of inspection and maintenance.—In one large factory a regularly developed method of inspection and renewals is employed. As an example the method as applied to several thousand tungsten lamps which are in service in the various buildings will be described. All the lamps are inspected once per day, except Saturday and Sunday. A regular route is followed by the inspector, and all burned-out lamps, broken switches, loose fuses, and similar items are noted. Careful observation is also made of reflectors which appear to need washing and any other points which might affect the efficiency of the system, after which a report is made up about noon and promptly sent to the maintenance department to permit all renewals and repairs to be made before night. In this manner the lamps are well maintained from day to day.

Marking columns.—To facilitate this renewal work, it has been found advantageous to mark all columns through this shop. The inspector is thus enabled to indicate clearly the location of each burned-out lamp and the renewal man to locate it without delay. It is helpful now and then in like manner to have the inspector note the unnecessary lamps found burning when artificial light is not required. If lamps are found burning at such times, a note sent to the head of the department calling attention to the matter is usually sufficient to remedy the difficulty.

Noting soiled reflectors.—As a check on a regular cleaning schedule, the inspector should note all reflectors in need of cleaning. The frequency of each cleaning will depend on the rate of deterioration due to the settlement of dirt on the surface of the glass or metal and also

on the surface of lamps, and the fact should be kept in mind that the amount of dirt on a reflector is nearly always deceptive; that is, reflectors which have suffered a large deterioration in efficiency due to dirt often appear fairly clean, and for this reason it is best to increase the frequency of cleaning somewhat over that which seems sufficient from observation, particularly in view of the fact that tests indicate large reductions of light from apparently small accumulations of dust and dirt.

A method of washing.—In the factory just referred to, all reflectors are removed to a central washing point. Where the number of reflectors to be hauled is large, a truck is used. Often, however, where only a small number of reflectors is to be transported, small hand racks, devised for the purpose, are employed. When an installation is in need of washing, the scheme is to haul sufficient clean reflectors to the location in question. The soiled reflectors are then taken down and clean ones immediately put into place, after which the soiled reflectors are removed to the central washing point, washed, and put into stock for the next location.

SECTION 12. EXPERT ASSISTANCE SUGGESTED:

The advantages of securing expert assistance in dealing with illumination is strongly emphasized. The points which come up for solution are complex and require, in many cases, the judgment of one who has had wide experience in the lighting field.

SECTION 13. OTHER FEATURES OF EYE PROTECTION:

Care is urged on the part of those responsible for the health and welfare of employees to see that adequate eye protection is afforded in all operations which are apt to cause injury to eyesight, if such protection is neglected. As typical of such other cause of danger to eyesight, arc welding may be mentioned, where the operator, according to accepted practice, must wear a helmet serving as an eye shield as well as a shield for the face and head in general. *Protective glasses for this purpose should not be judged as to their protective properties by mere visual inspection. They should, however, be analyzed for their spectral transmission of invisible radiation.* Protective measures should also be taken to prevent onlookers from being unduly exposed to such eye dangers, by inclosing the welding operations with suitable partitions. These general remarks apply with equal force from the standpoint of those handling the operations to such other cases as the testing of arc lamps, inspection of hot metal, and similar cases.